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THE FORMATION PRINCIPLES OF NON-STOP SUBURBAN BUS SERVICE

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Regional transportation of passengers by buses in regular connection can be carried out according to the following schemes [1, 2]:

– transportation on a route according to a strict schedule;
– transportation on the route with additional flights performed as needed;
– transportation according to the established interval of bus traffic.

Interval transportation is used at a high intensity of passenger traffic, for example, in urban transportation.

Transportation on a route according to a strict schedule involves the execution of flights by buses of different capacities, which move strictly according to the schedule and set days of the week. With this scheme, the carrying capacity on the route for the period is fixed. Therefore, due to the randomness of the intensity of passenger traffic, with this scheme, on some days the carrying capacity turns out to be insufficient, and on others - excessive. In case of insufficient carrying capacity, passengers are forced to use either other types of transportation or other types of transport (taxi cars, rail transport, etc.), or postpone the trip for a later date on this or another day. With excessive carrying capacity, the use of bus capacity decreases and, as a result, economic costs per unit of transport work and emissions of harmful substances increase. In order to reduce the impact of the randomness of the intensity of passenger traffic on the route, additional flights on the route are additionally used, which are performed as needed. When the increased passenger traffic is ensured by additional flights. The work considers making optimal decisions about the use of a fixed traffic schedule, taking into account the interaction with other routes. This, in turn, will make it possible to increase the overall productivity of the fleet of rolling stock and ensure the formation of an additional reserve of transportation capacity, which will allow to eliminate the need for the use of reserve flights during the increase in transportation demand.

The task of synchronizing the traffic schedule in intercity traffic involves coordinating the moments of arrival and departure of buses at points of interaction. To do this, it is necessary to form a model of the interaction of route flows in the form of a topological diagram of the transportation area. Figure 1 shows the topological diagram of the transport network of the district serving the intercity bus route Kremenchug - Kharkov.

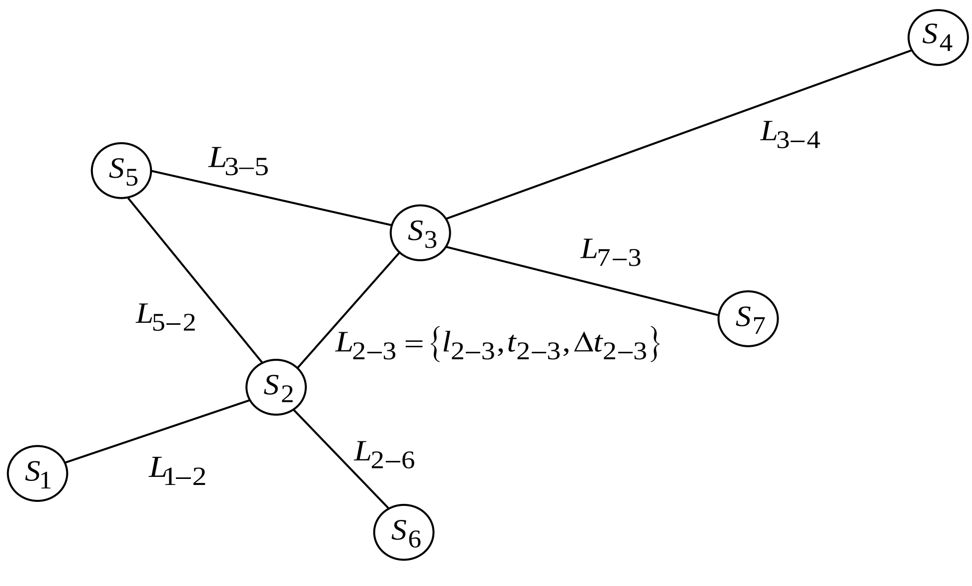

Figure 1 – Topological diagram of the route service area

The network consists $S_n = \{S_1, S_2, ..., S_n\}$ of stopping points where passenger flows $F = \{f_{1-5}, f_{5-1}, ..., f_{i-j}\}$ and route flows are formed $M = \{m_{1-5}, m_{5-1}, ..., m_{i-j}\}$. The following nodes are marked in Figure 1: S_1 – Kremenchug, S_2 – Butenky, S_3 – Poltava, S_4 – Kharkov, S_5 – Kyiv, S_6 – Dnipro, S_7 – Krasnograd. Network points are connected by links $L = \{l_{1-5}, l_{5-1}, ..., l_{i-j}\}$. Each link of the network is characterized by: length (l_{i-j}), time (t_{i-j}) and level of time movement deviation (Δt_{i-j}). The time of arrival at each point $T^n = \{\tau_1^n, \tau_2^n, ..., \tau_i^n\}$ and departure $T^o = \{\tau_1^o, \tau_2^o, ..., \tau_i^o\}$ is decisive for ensuring the conditions of synchronization of passenger transfers. In each direction, the movement of route vehicles is carried out, which collectively forms the transport capacity in each connection $W = \{w_{1-5}, w_{5-1}, ..., w_{i-j}\}$. Transportation capacity depends directly on the number of buses $A = \{A_{1-5}, A_{5-1}, ..., A_{i-j}\}$ and their capacity $G = \{g_{1-5}, g_{5-1}, ..., g_{i-j}\}$. The main form of manifestation of the transport offer is the number of flights on the connection route.

During the operation of complex transport systems (including long-distance passenger transport), the objects included in them constantly exchange information. The change of such transport systems over time has peculiarities. So, in order to maintain its efficiency, any participant in the transport process constantly receives information from the external environment and other participants using means of communication, processes it and manages its behavior (for example, during the flight, the dispatcher receives information from the driver about the filling of the bus , and he transmits this information to the bus station dispatcher, which makes it possible to inform passengers in advance about the availability of free seats on the bus).

An input-output model is a description of the connection between input and output signals of a dynamic system. The need for such a description arises when considering the behavior of individual blocks and, in particular, the control object, and the entire control system in general. The differences in the mathematical description of the blocks and the control system are unprincipled, but require the use of different notations. In any management process, there is always an interaction between two objects - the manager and the managed, which are connected by direct and feedback channels. Control signals are transmitted through the direct communication channel, and information about the state of the controlled object is transmitted through the feedback channel.

However, in the case of modeling the control system, it is not always convenient to use a detailed model to determine the criteria for its effectiveness. It is necessary to provide such a form of representation that will allow highlighting the main characteristics of the management system. We can determine the boundaries of the organization of the transport process as a system interacting with the external environment, using the main objects included in the "transport process" system. Such a list of objects includes: input flows, external influences, controlled quantities and the output in the form of performance evaluation indicators.

For modeling, it is suggested to use the general model of the research object. This is determined by the simplicity of the graphic language. The methodology is based on four main concepts: the first is the concept of a functional block (the block is graphically represented in the form of a rectangle and represents a specific function within the analyzed system); the second concept of the methodology is information arcs (a graphic representation of such an arc is a directed one-way arrow); the third basic concept of the standard is decomposition (the principle of decomposition is used when breaking down a complex process into its functions); the last of the concepts is the summary.

If the control process does not take into account the state of the controlled object and provides control only from a direct channel (from the control object to the controlled), such control systems are called open. The information model of the open control system for the organization of passenger transport services on the intercity route, taking into account the conditions of traffic synchronization with adjacent routes, can be visually presented using a diagram.

Based on the analysis of the functional relationships of the research object, it is possible to form a general model of efficiency assessment. Such a model, which describes the parameters of improving the efficiency of the route, can be presented in the form of a «white box» model, shown in Figure 2.

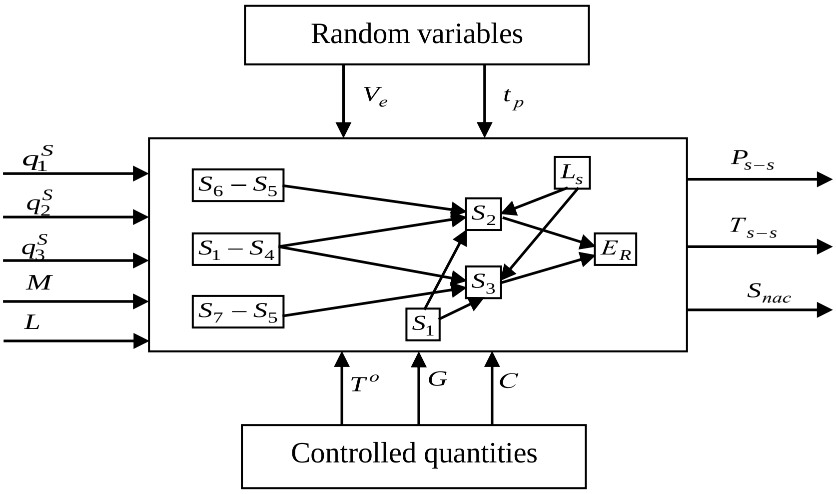

Figure 2 – A «white box» model describing the parameters for improving the efficiency of the route

The input values of the model include: q_1^S – the number of passengers departing from the initial point, pas., q_2^S – the number of passengers changing at an intermediate point S_2, pas., q_3^S – the number of passengers changing at an intermediate point S_3, pas., M – the time of transition between points transfers, hours, L – length of route sections, km. The random variables of the model include: V_e – speed of movement along the route, h. t_p – time of movement along sections of the route, h. Controlled values of the model include: T^o – time of departure from the starting point, hours, G – bus capacity, pas., C – operating costs of the bus, UAH/km and UAH/hour. The output values of the model include: P_{s-s} – the possibility (probability) of a transfer, T_{s-s} – the transfer time, hours, S_{nac} – the cost of transporting a passenger, UAH/pass.

The presented connections and the general model of the white box are the basis for choosing the efficiency criterion and developing a set of analytical models for determining the rational parameters of the route under the conditions of ensuring the possibility of synchronizing the traffic schedule on the routes.

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